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The Case of Corning Pyrex® Acid-Waste Drainline

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Introduction

The utilization of technology in products or processes beyond the scope of the original development effort can be considered "technology transfer". Selected examples of this transfer may, in retrospect, appear as seemingly uncomplicated events spurred by mere common sense or logical extension of the initial idea; yet available evidence indicates that the process of technology transfer is in fact complicated and tedious. Because of a widespread interest in speeding economic growth through technological development, and the particular interest of the National Aeronautics and Space Administration in fostering commercial adoption of the great body of technology developed during the course of research associated with the space effort, we have analyzed closely a number of instances of successful technology transfer. Our hope is that in a growing body of such case studies will be found clues as to the critical variables in this process.

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The following case was selected from among many we have encountered because of the general applicability of the principles which it illustrates. First, technology transfer which results in a new product is a complex process which requires a combination of factors including tedious development work, imaginative individuals, and luck. The final product is apt to combine individual, but diverse, links of technology, each one of which is necessary for product feasibility. These links have probably originated from a number of different sources. In the development process reported below, we can identify the use of technological information derived from the following sources: an invention by the subject company some 50 years previous and widely used in company products; a product improvement announced by a materials supplier at a crucial point in the development stage; a new process, previously developed by the R&D department, which was never used but maintained "on the shelf"; and several commercially-available materials discovered through the use of vendor catalogues and a materials information service to which the company subscribes.

The second principle point which emerges from the case analysis is that even when the development of a carefully-engineered, economically-feasible product has been completed, a well-planned marketing program is required if the product is to be accepted and thus contribute to company profits and national economic efficiency. While the importance of marketing to product success is generally recognized, it assumes dominant importance in the complex, semi-public market for acid-waste drainline, where the phenomenon of "institutional drag" serves to inhibit new-product introduction and thus slow the process of technology transfer.

<u>Acid-waste drainline background</u>

The Corning Glass Works, which ranks about 400th among U.S. corporations in annual sales, produces a wide range of glass products. One of its recently-added industrial lines is Acid-Waste Drainline, made from Pyrex® brand glass, a chemical- and heat-resistant material. Drainline is purchased by mechanical contractors for installation in buildings which house chemical laboratories requiring sinks for the disposal of all kinds of acids. Examples of such buildings include high schools, college laboratories, hospitals, and industrial or government research labs. The requirement is for a drain installation which will carry the corrosive wastes to a place of recovery or harmless dissipation, outside of the building.

Until the introduction of glass by Corning a special type of cast iron with a high silicon content was widely used for the drain installations. Currently, glass has a major share of the market. Corning is the principal supplier and one competitor, Owens-Illinois, has emerged in the glass drainline market. The high-silicon content cast iron is supplied now by one major firm since the second supplier closed its plant in January 1968. Although we have not studied the withdrawal of this second supplier, its plant closing offers testimony to the competitive success of the Corning product.

Chemical and heat resistant glass was developed by Corning in 1912 expressly to solve heat-shock problems on railroad signal equipment. This then, is the fifty-year old technology which was widely used in other corporate product lines. In 1915, it was adapted to cookware, in 1919 to labware, and in 1922 to pipe for the chemical-processing industry. The basic patents have expired, but the brand name "Pyrex[R]" is copyrighted and owned by the Corning Glass Works. Major features of this glass are that it is highly resistant to sudden temperature changes, is corrosion resistant, and is not easily shattered.

Prior to 1958 Corning's contact with the problem of acid waste disposal was in connection with Pyrex installations for large commercial and industrial laboratories and photoengraving plants. These drainlines wereccustom assembled from standard glass pipe and fitting components already used in the chemical industry, plus a few fittings (traps, elbows, etc.) added to the standard line. The severe service conditions in such facilities justified the higher initial cost of a custom glass installation, in comparison with the special cast iron, because of its clear superiority in acid resistance. In contrast, the more normal laboratory conditions in schools and hospitals favored the high-silicon iron on a lifetime-cost basis.

Corning representatives occasionally bid on such normal jobs and were sometimes successful. But Corning's market penetration was slight. In addition to the higher cost of the custom installation, additional barriers to widespread usage existed in the form of widely-accepted practices among architects and design engineers for public buildings. These practices required the setting of specifications in such a way that more than one supplier could compete for the job. Thus, if a custom installation by Corning were to be specified many procedural problems would arise for the architects, the contractors, and the organization contracting for the construction.

In the spring of 1958, the marketing manager of the industrial products department, which sells glass pipe and related equipment to the chemical industry, was on a routine customer visitation trip with one of Corning's field representatives. They were concerned with some technical problems not related to the acid waste problem. The representative, however, had just recently tried to sell Corning's custom drainline installation and had been impressed with the extreme difficulties of making such sales. He, accordingly, challenged the marketing manager to apply his talents to the technical design of a generally marketable drainline installation. This was the initial stimulus to the development of the new product.

The reported difficulties in marketing Corning's custom installations for acid waste disposal in chemical labs were verified. Then, Corning's market research department prepared a market survey to determine the sales potential of a glass product which would be competitive with high-silicon iron. Once it was determined that a potentially profitable market did exist a decision was made to undertake the indicated development work.

The Development Process

The first step in the development work was to establish product criteria, followed by general specifications of performance and installation characteristics. Thus, Corning wanted a product which could be installed in the field by plumbers regularly engaged in building construction; they anticipated some resistance by plumbers to a new product but felt this could be overcome as long as plumbers' skills were required. Also, the installed drain had to withstand a sufficient amount of pressure to meet the most stringent building codes. Finally, the sales price was required to be competitive with that of the already used high-silicon iron, and the margin and return on investment to Corning were required to exceed minimum corporate standards.

It was readily determined that the piping could be made from Pyrex® brand glass with a wall thickness adequate to meet the pressure requirements. Cost estimates showed that the pipe could be manufactured within the cost and price requirements; i.e., on a linear-foot basis the pipe could be sold at the same price as the special cast-iron pipe and return more than the required margin. In fact, it was estimated that manufacturing direct cost of the high-silicon iron pipe was greater than that of the glass, thereby affording ample protection to Corning should a price war develop.

One technical problem concerned the molding process for the pipe fittings---elbows, tees, and so forth. The specifications for Pyrex® fittings required molding capabilities beyond those being used on standard industrial product lines. The problem was referred to the corporate research and development department. Here a process originally developed some years previous for the consumer dinnerware line, and never used there, was found suitable. Thus internal technology maintained "on the shelf" provided a ready answer to a critical problem and a link in the technology transfer chain.

The key technical problem to be overcome required a device or process whereby the standard glass pipe sections could be coupled together on the construction site by regularly-licensed plumbers. It was also necessary to include in this coupling process a method of cutting standard lengths of pipe for shorter, but required lengths, and a method of installing a bead on the cut end of the pipe.

The problem was turned over to a design engineer in the Product Development Department. His instructions were to develop a solution which exploited the technological superiority of glass in conducting acids. In effect, this instruction required that the joining mechanism be as durable as the glass. This objective was to be achieved within the economic constraints previously noted.

The ultimate solution to the problem was a coupling which combines three different materials in a unique way. The inner part is a bracelet-like circle of Teflon* with an inward-projecting circular flange centered so as to serve as a pressure-proof gasket for the ends of the two pieces of pipe being joined. This Teflon gasket is in turn surrounded by a sleeve of rubber extending beyond the Teflon. Finally, a semi-hinged band of stainless steel encloses the rubber sleeve. A bolt-and-nut arrangement on the bank permits the coupling to be tightened firmly in place. A prerequisite to the feasibility of this coupling was the presence of an enlargement (or bead) on the ends of the pipes to be joined. A machine for cutting the glass in the field and for heating it so that a bead could be molded on had to be developed.

Choice of materials

The marketing manager initially suggested to the design engineer that Teflon was a potential material for use in the inner gasket. It had been used elsewhere in Corning and was known to be acid-resistant as well as durable. For eighteen months the engineer attempted to develop a process for shaping the Teflon into the desired form without exceeding the material's cost constraints. He met with little success. At this point a new variant of Teflon (FEP) was made available by DuPont. Experiments were tried on the new material and it proved to have the properties which permitted it to be shaped as desired. Thus, new technology (in the form of a new material) developed by a supplier held the

* Reg. trade mark of DuPont.

key problem solution.

The need for a material to cushion the impact of the outer metal collar was obvious. The problem was to find a material which would not deteriorate significantly over time. The cushioning properties of rubber were obvious, but the lack of durability of the more common types was a drawback. The special rubber compound finally selected had the required cushioning properties and was also resistant to acid fumes, heat and other corrosive elements in the air.

The metal to be used for the outer collar had to resist rust and other types of corrosion, and additionally be sufficiently strong to carry the weight of the pipe as well as to maintain the required pressure on the gasket for a "lifetime." Stainless steel was chosen because it satisfied the requirements. On both the selection of the special rubber compound and the particular type of stainless steel, Corning engineers referred to both vendor catalogues and a commercial materials information service.

Subsequent product improvements

The history of Corning's acid-waste drainline since its introduction to the market in 1960 has been one of success. There were many problems to be solved, not all technical. Thus, plumbing codes had to be modified in most areas to permit its use. Training of plumbers to use the special equipment necessary for the glass installation had to be accomplished in the face of their initial reluctance to work with glass.

In fact, the development of the machines to be used in the field to provide the cutting and the beading of the glass had to be carried out. In 1963, competition developed from another glass manufacturer, Owens-Illinois. Since one producer of cast iron pipe left the field in January, 1968, there remains but one major supplier.

As Corning penetrated this market a need developed to simplify the field fabrication of odd lengths of pipe. The cutting and beading machines were satisfactory, but marketing personnel reported that sales would benefit from a faster and simpler jobsite fabrication technique. This problem, with definite cost and performance criteria, was given to the development department in 1965.

The technical problem centered on the heating and cooling associated with putting the bead on the cut pipe in the field. Among other things, incorrect cooling could put the pipe in a condition of stress which might result in breakage. There was no foolproof method of assuring that the installing plumber would exert the necessary care. Adequate cooling required waiting time which, if not used productively, raised labor costs.

It was clear that an easier process for enlarging the end of the cut pipe would both assure the quality of the installation and reduce sales resistance. Once again a search for appropriate materials was made. Eventually, a bead substitute in the form of a collar made of Teflon with an attached band of stainless steel was developed. This collar is fitted to the end of the cut glass pipe and crimped tight with a pair of pliers.

The metal band is bonded to the glass with a special adherent material which requires the application of heat, provided by a specially-designed heater inserted into the pipe.

The use of the above described device makes the old glass beading process unnecessary. However, the process still requires the use of heat in order to "set" the mastic in a permanent seal. There is a need for a mastic which is permanent but which does not require heat. Development work continues on the process. A major objective of this search is to reduce or maintain the costs to Corning but at the same time produce a more easily used and thus more marketable product.

Marketing: Problems and Resolution

By examining the marketing problems faced by Corning we gain insight into the real obstacles which often serve to slow the technology transfer process. Throughout the design and development stage product engineers were constrained by an early marketing decision that the final system be price competitive with the silicon-iron pipe. It was decided to sell the fittings (elbows, tees, and so forth) at the same unit prices as the high-silicon iron fittings, but the pipe was priced lower. The Corning system, however, requires couplings where the other system does not. Thus, cost of materials under the glass drainline system is higher.

Despite the durability and other product advantages of the glass system, Corning's marketing personnel determined at an early stage that it could be sold to mechanical contractors only on the basis of a cost savings. Thus sales presentations emphasize the lower installed cost which results from labor savings of up to 50 per cent.

These savings arise because of the amount of time required to install cast-iron pipe. Each joint must be leaded, a time-consuming task; and since the weight of the pipe dictates shorter lengths than those of glass, significantly more joints are required. The lower weight of the glass also permits the use of fewer pipe hangers, and hence provides further labor and material savings.

The selling point for glass drainline is thus that the extra cost of the required couplings is more than offset by the labor economies of installing glass pipe, as opposed to iron. Sales training materials are designed to teach field personnel how to compute and illustrate these economies.

Although Corning determined early how to sell its new product, the focus of the sales effort (who had to be sold) was, and remains, unclear. The drainline market is representative of a complex, public-industrial market, influenced by a great number of interest groups, in which the locus of decision-making (purchasing) authority is not clearly known to the seller, and may in fact vary with each potential customer. In these markets technology transfer which results in the success of a new product can only be achieved if the product's merits are brought to the attention of all relevant interest groups.

By way of illustration, if a university is constructing a new chemistry lab, all of the following parties may require convincing presentations regarding the suitability of glass acid-waste drainline:

1. Plumbing wholesaler;
2. Mechanical contractors;
3. General contractors;
4. Owner (university), including possibly each of the following subgroups:
    a. building committee
    b. buildings and grounds' personnel,
    c. business manager,
    d. chemistry professors;
5. Architect;
6. Mechanical engineer (who writes the specifications);
7. Local and/or state building code authorities;
8. Laboratory furniture manufacturers.

Some of the ground work must be done far in advance, perhaps several years, of the actual sale. Obviously a local plumbing wholesaler must have agreed to carry the line if it is to be available for purchase by the mechanical contractor. The actual sale by Corning is to the plumbing wholesaler through a manufacturer's representative. Before agreeing to carry the line, the plumbing wholesaler is likely to require assurance from local plumbers that they will install the new product, so that an additional interest group might be added to the list.

The manufacturer's representatives task is, thus, not confined to selling to wholesalers. He must keep aware of new building plans within his territory and see to it that all concerned parties are aware of the system and its capabilities. If the specifications of a particular job call, for example, for high-silicon content cast iron drainline, the sale of glass is virtually precluded; so the mechanical engineers must be convinced of the logic of writing performance specifications.

Although it may be possible for the mechanical contractor to adopt Pyrex® drainline after winning the bid, in many cases he must specify the type of material to be used in advance of the contract award. This may require that eight or ten potential contractors be contacted in advance of the competitive bidding.

In the early stages of Pyrex® drainline marketing the principal obstacle to sales was the existence of building codes requiring the use of the established cast iron drainline. Intensive effort on the part of the network of representatives has succeeded in rewriting many of these codes to allow the use of glass drainline.

It is clear, then, that marketing of specialty products in the scientific building construction industry presents a complex problem; and that new products must overcome a series of difficult obstacles before widespread acceptance is achieved. Careful long-range planning of marketing strategy is required if technology transfer is to successfully overcome the "institutional drag" which characterizes this industry.